BLiX
Berlin Laboratory for innovative X-ray Technologies

A novel High Average Power High Brightness Soft X-ray Source using a Thin Disk Laser System for optimized Laser Produced Plasma Generation

I. Mantouvalou, K. Witte, R. Jung, J. Tümmler, G. Blobel, H. Legall, B. Kanngießer and H. Stiel

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Outline

1. Motivation
2. Laser system
3. LPP setups
    1. Liquid jet technology
    2. Rotating cylinder target

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1 Motivation: soft X-rays

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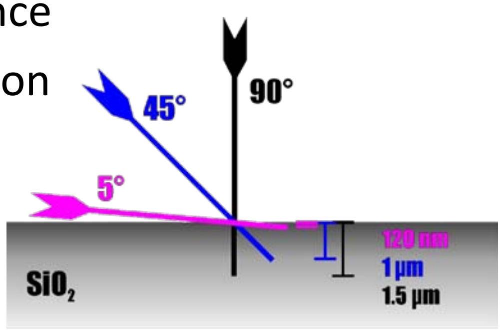
X-ray emission spectroscopy

Grazing incidence

for nm-resolution

…

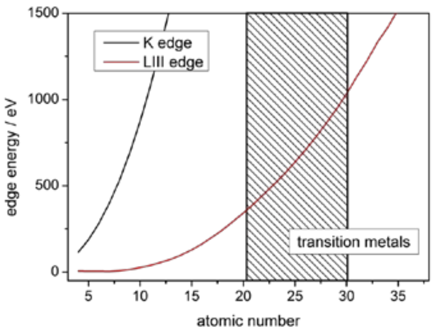


X-ray absorption spectroscopy

L-edges of transition metals in solution

Biological samples

…

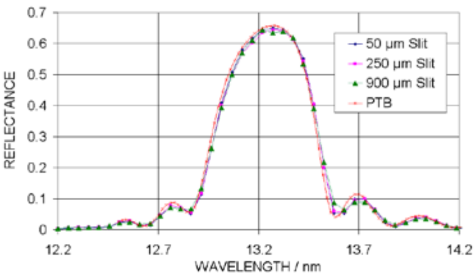


EUV metrology

Reflectivity

Foil thickness

…



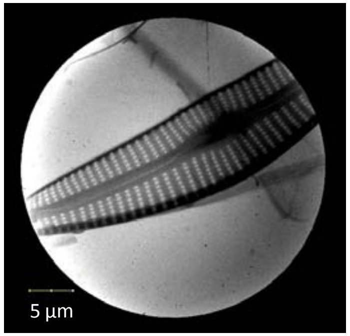
Imaging

Microscopy in the water window

Coherent imaging

Holography

…



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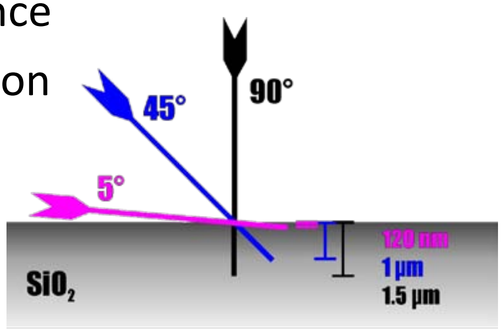

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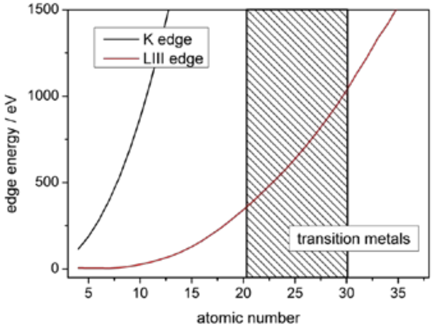

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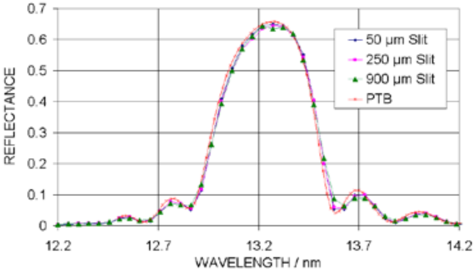

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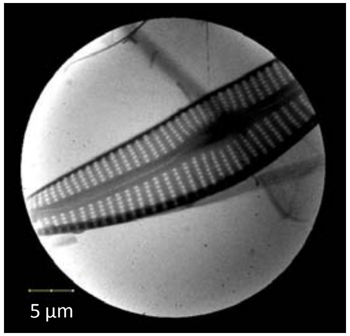

Goal: lab-based equipment

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2 Pump Laser

High brilliance:

1. High single shot intensity
2. High repetition rate
3. Good beam quality & stability

$\Rightarrow$ diode-pumped YAG-laser systems

slab system | thin disk laser system

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slab system thin disk laser system

2 Laser system

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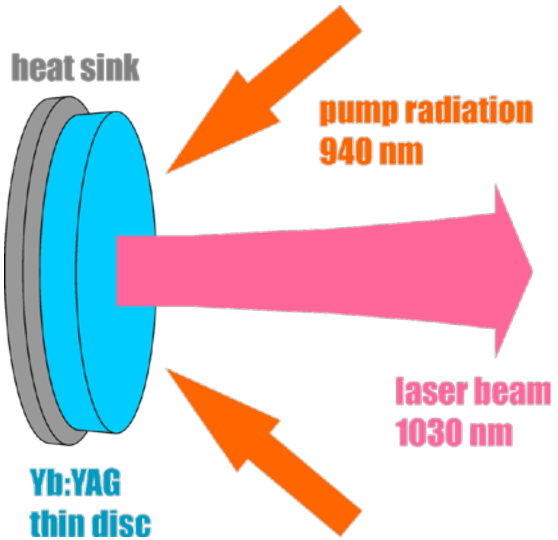
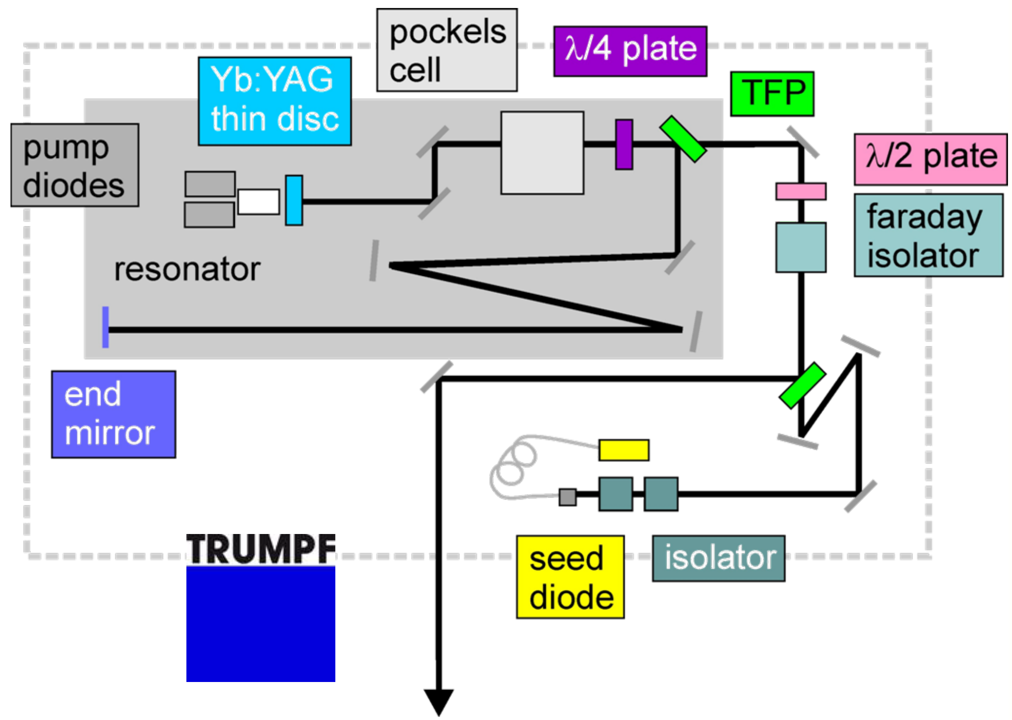
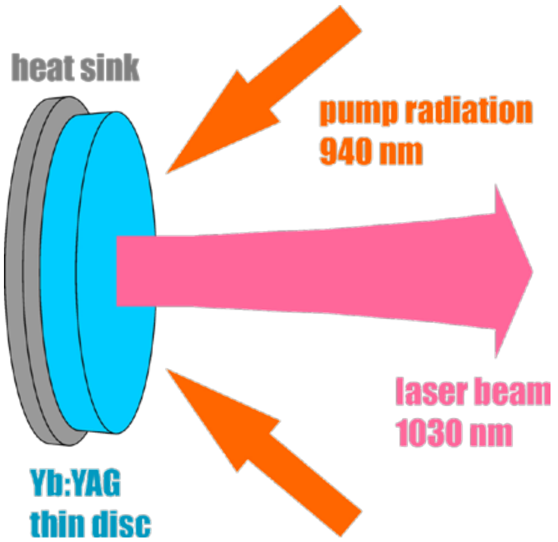




pulse energy	220 mJ
pulse duration	10 ns
repetition rate	>100 Hz
mean power	> 15 W
M^2	<1.2

2 Laser system



pulse energy	220 mJ
pulse duration	1 ns
repetition rate	>100 Hz
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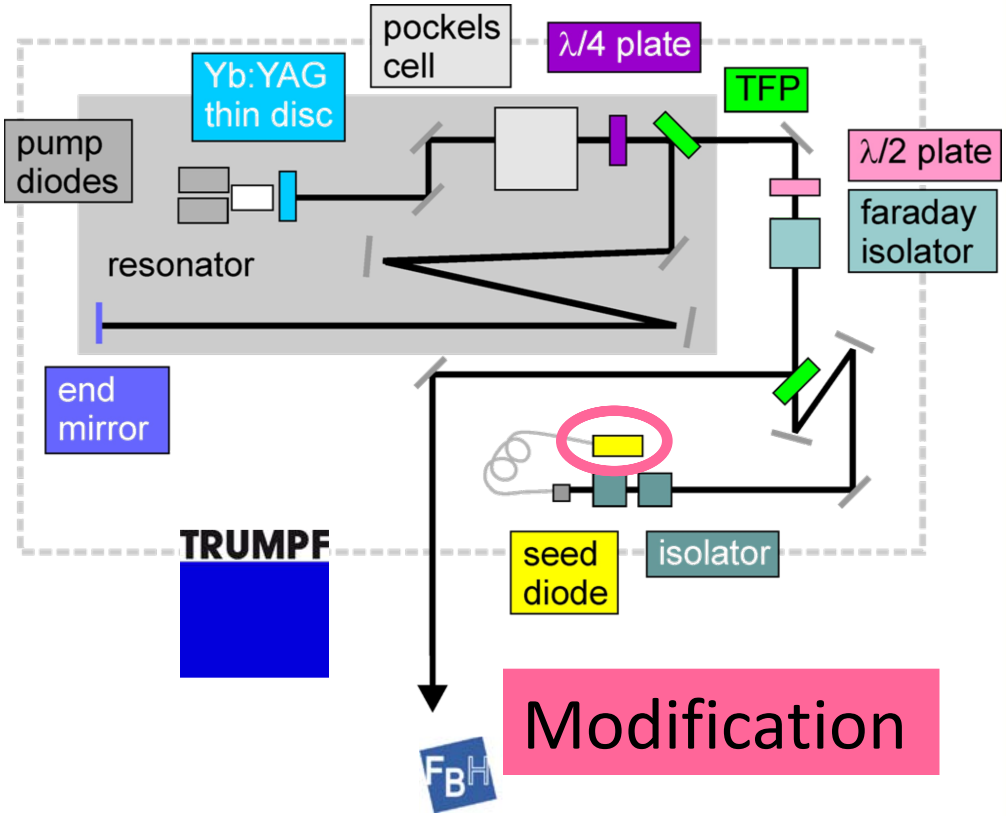

2 Beam characteristics

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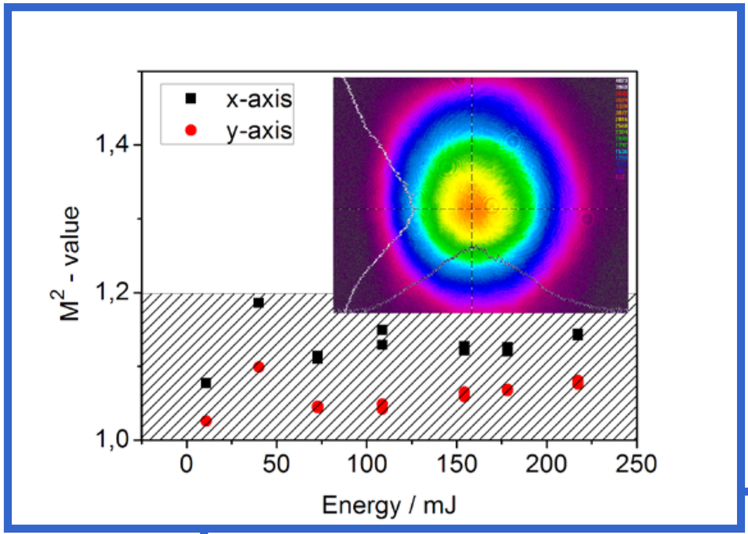

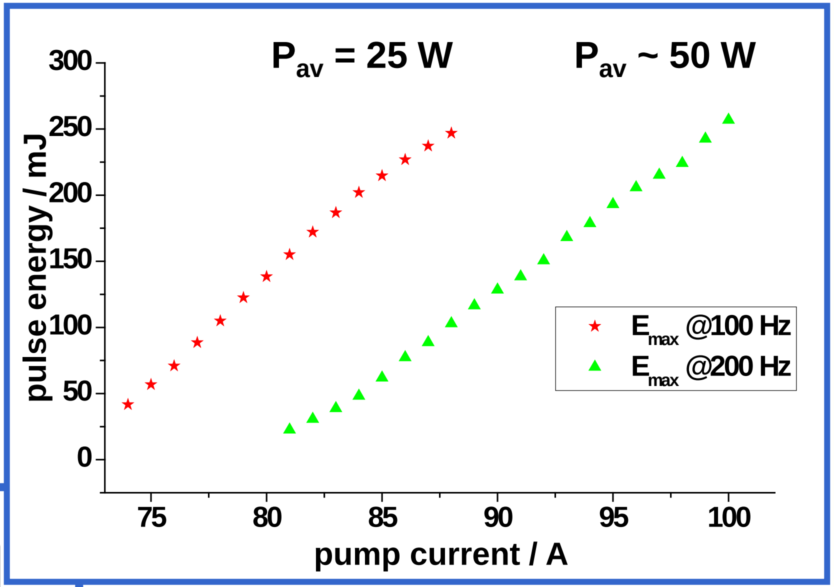

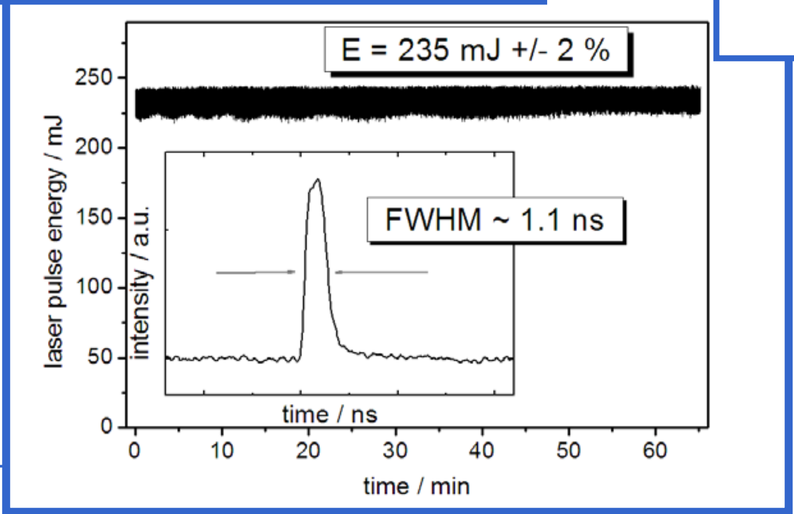

Stable performance:
235 mJ @ 1.1 ns
Regenerative system:
shorter pulse durations possible

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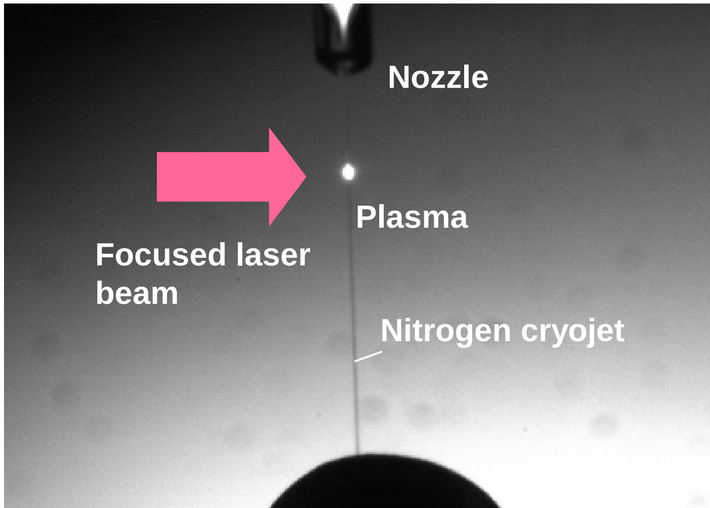
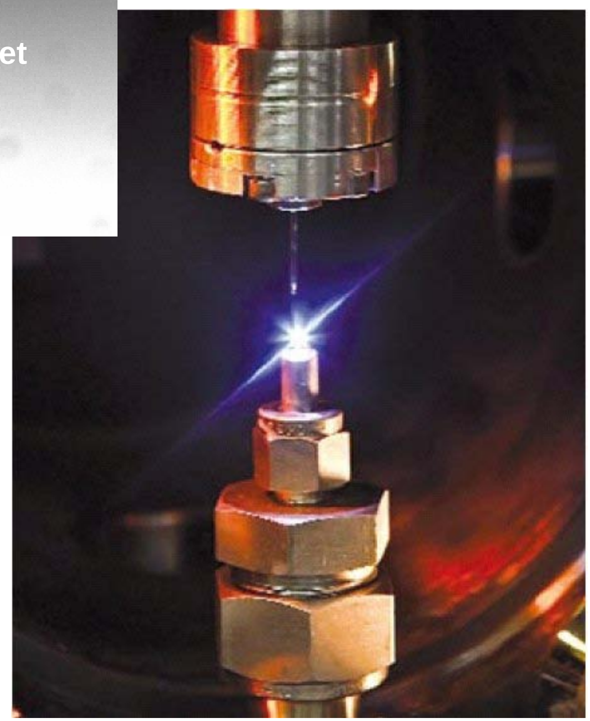
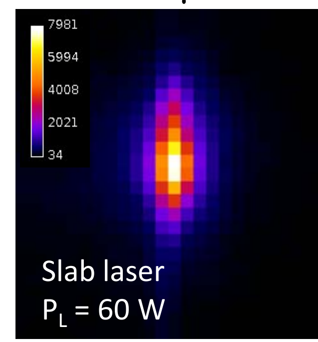
3.1 Liquid jet system



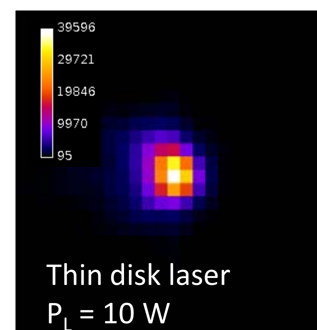


Source size

Slab laser
18x40μm



Thin disk laser
18x21μm



3.1 Liquid jet system

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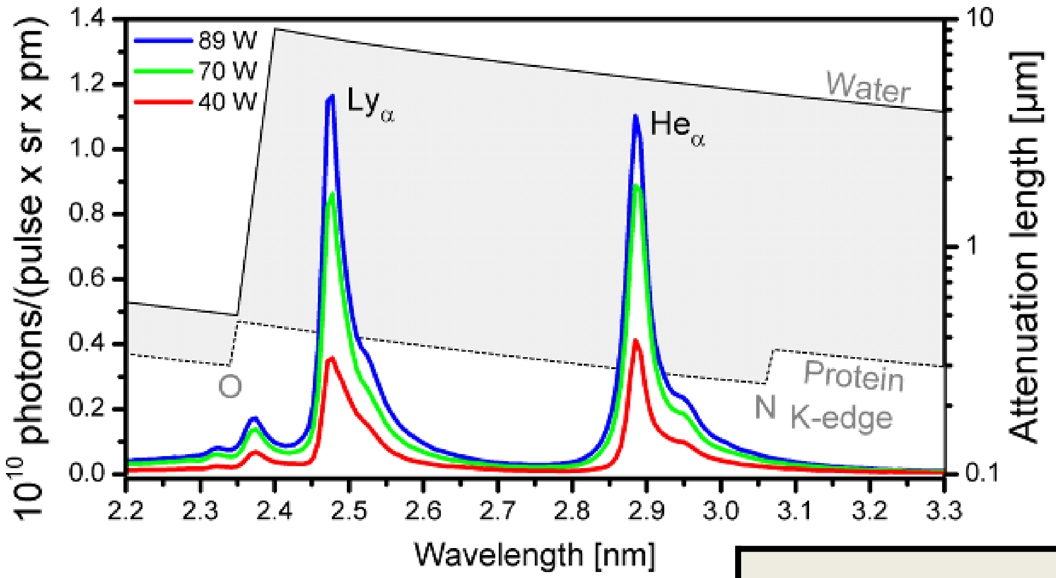


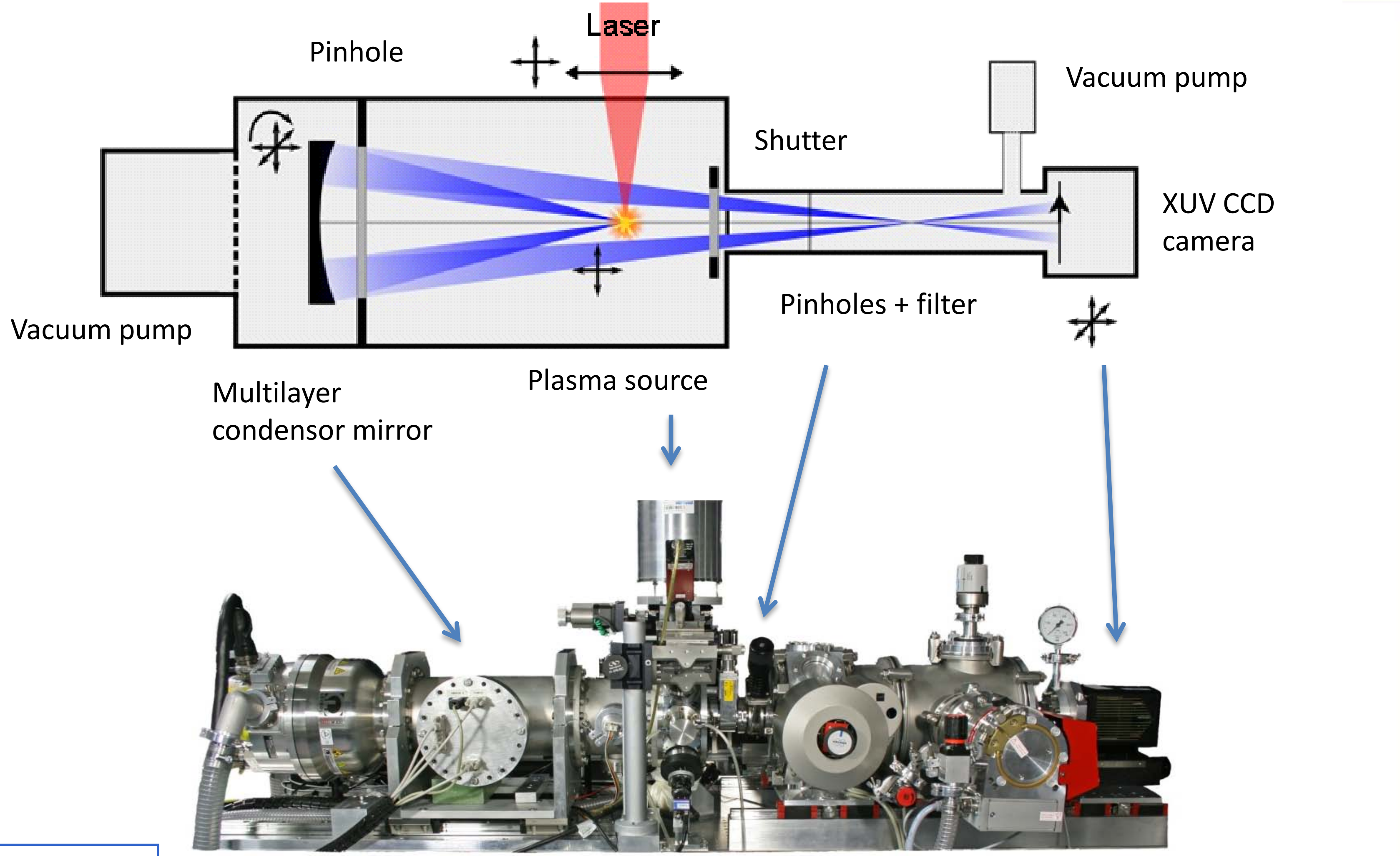
→ for EUV imaging and metrology:

use water jet instead of liquid nitrogen !*

	Slab laser	Thin disk laser (100 Hz)
E (mJ)	65	170
τ (ps)	450	1000
P (W)	90	17
ph/ s sr	$6*10^{14}$	$7*10^{13}$
ph/s mrad² mm²	$8*10^{11}$	$2*10^{11}$

** H. Stiel, U. Vogt et al. SPIE, 4343, 535 (2001)*

3.1 X-ray microscope



3.1 X-ray microscope

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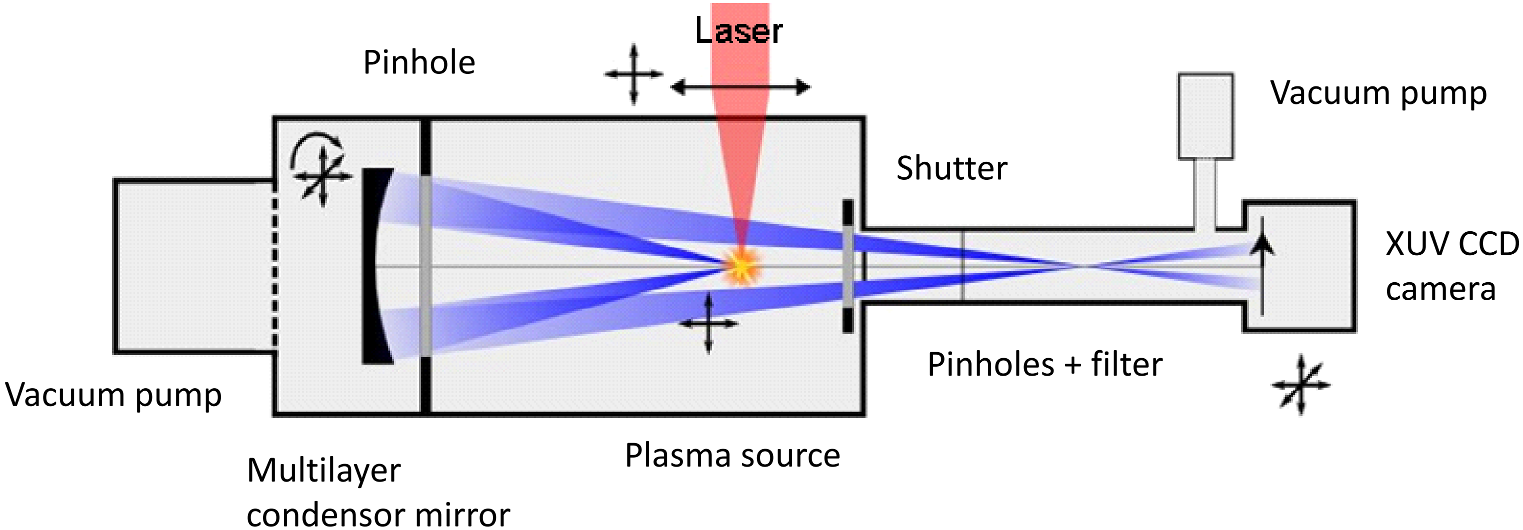
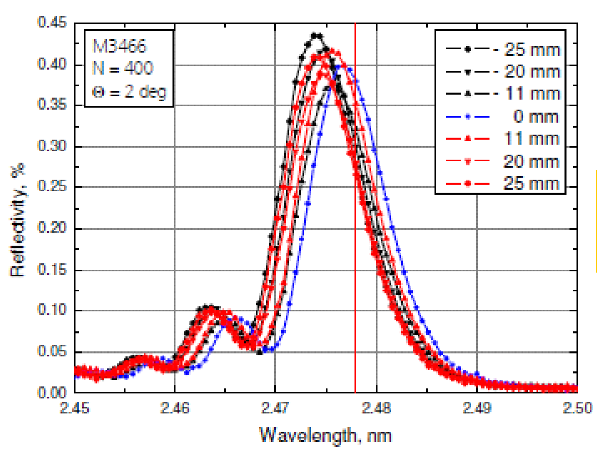
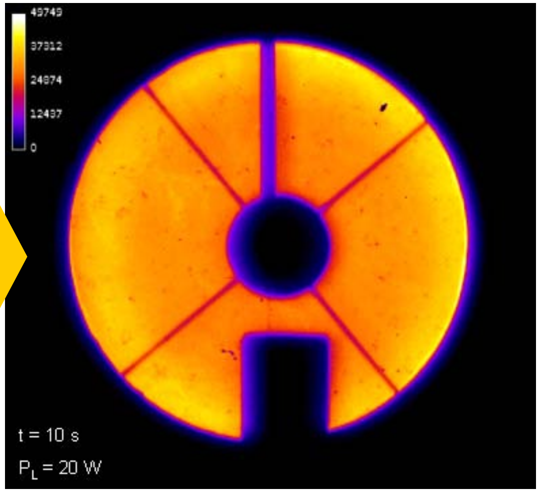


Fraunhofer
IOF





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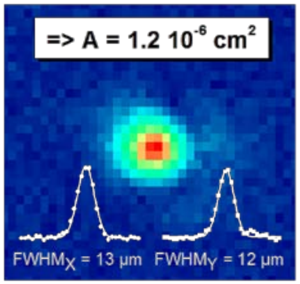
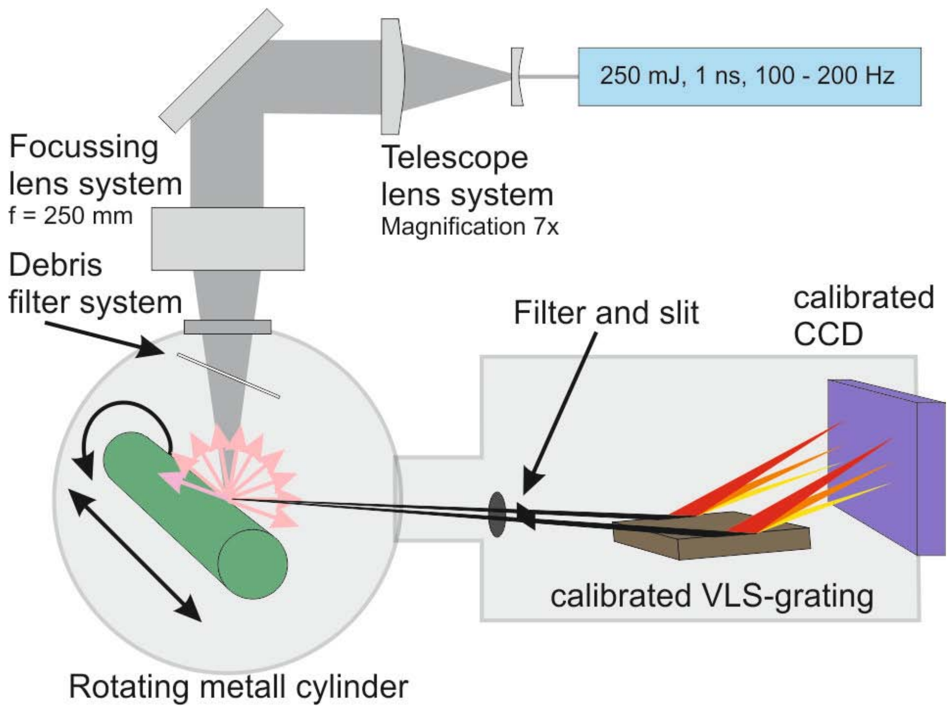
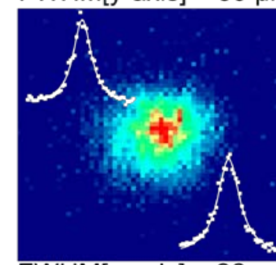
3.2 Cylinder target



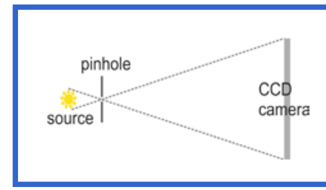
Optimal heating for 2 nm



FWHM[y-axis] = 30 µm



FWHM[x-axis] = 36 µm



Variable-line spaced grating spectrograph & Transmission grating spectrograph

3.2 EUV/XUV spectra

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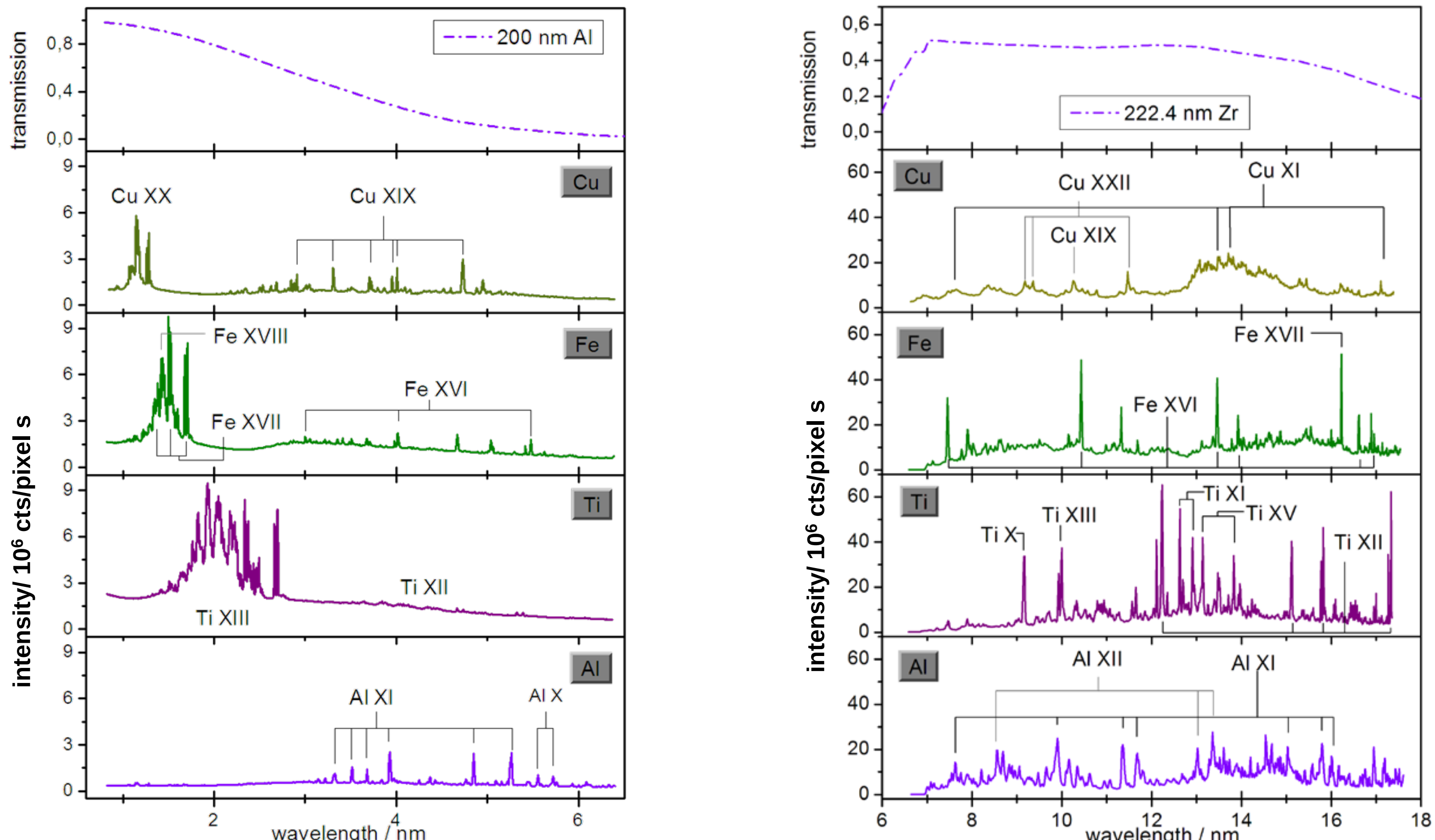
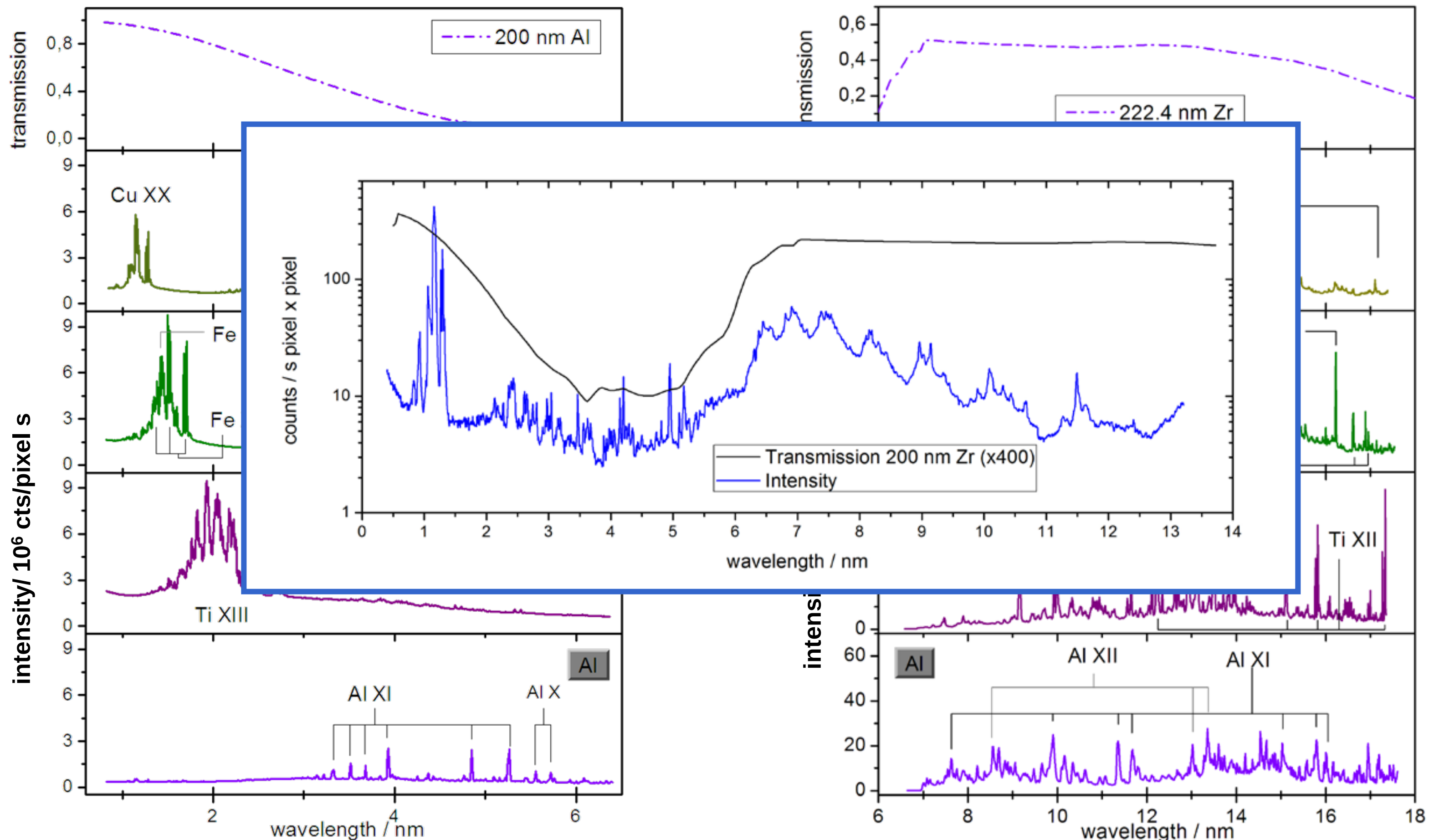


I. Mantouvalou et al. Rev. Sci. Instum., **82**, 066103*(2011)*

3.2 EUV/XUV spectra



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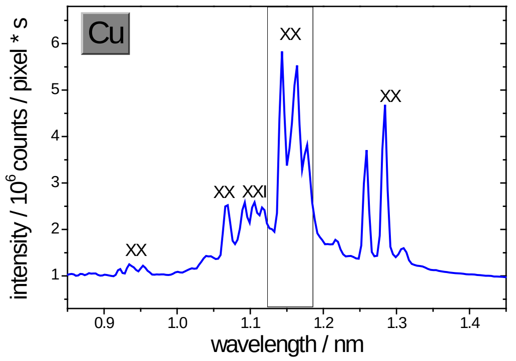
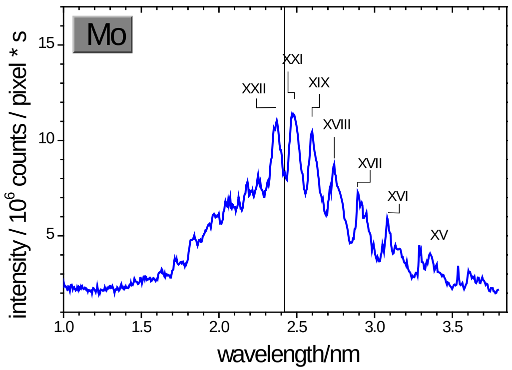
3.2 VLSG spectrograph

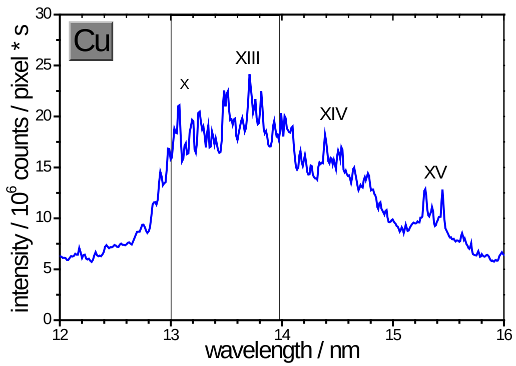
XUV: 1 nm region



XUV: water window



EUV: 13.5 nm region



	XUV 1 nm region	**XUV water window**	**EUV 13 nm region**
target	Cu	Mo	Cu
ph/ s sr line	$8*10^{12}$	$6*10^{14}$	$2*10^{14}$
ph/s mrad^2 mm^2 line	10^{10}	$7*10^{11}$	$3*10^{11}$

3.2 TG spectrograph

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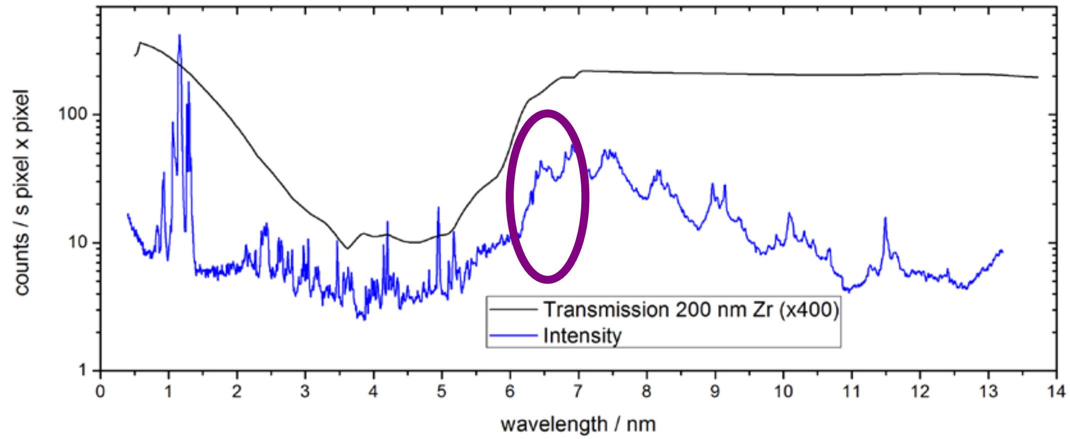
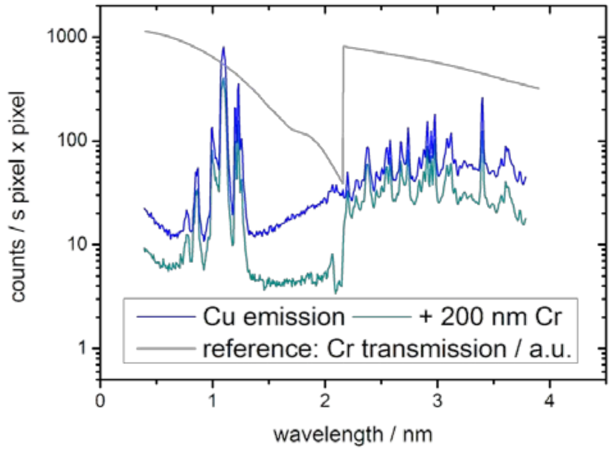
Broadband source:
Filter calibration
XANES/NEXAFS
Selection of suitable energy





	XUV 1 nm region	XUV water window	EUV 13 nm region	EUV 6.5 nm region
target	Cu	Mo	Cu	Cu
ph/ s sr line	$8*10^{12}$	$6*10^{14}$	$2*10^{14}$	$1*10^{14}$
ph/s mrad^2 mm^2 line	10^{10}	$7*10^{11}$	$3*10^{11}$	$2*10^{11}$

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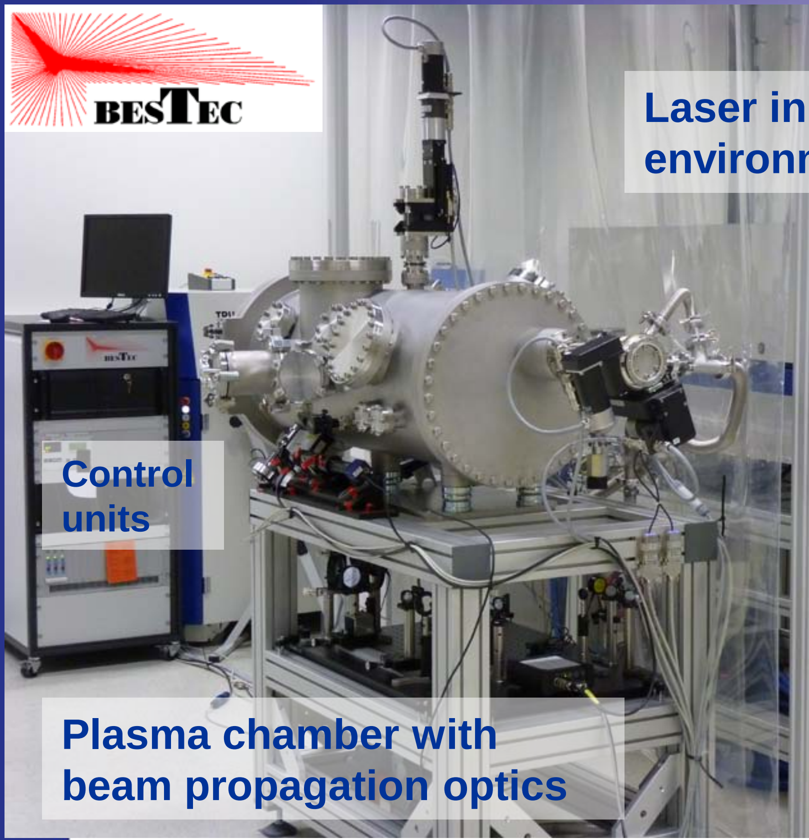
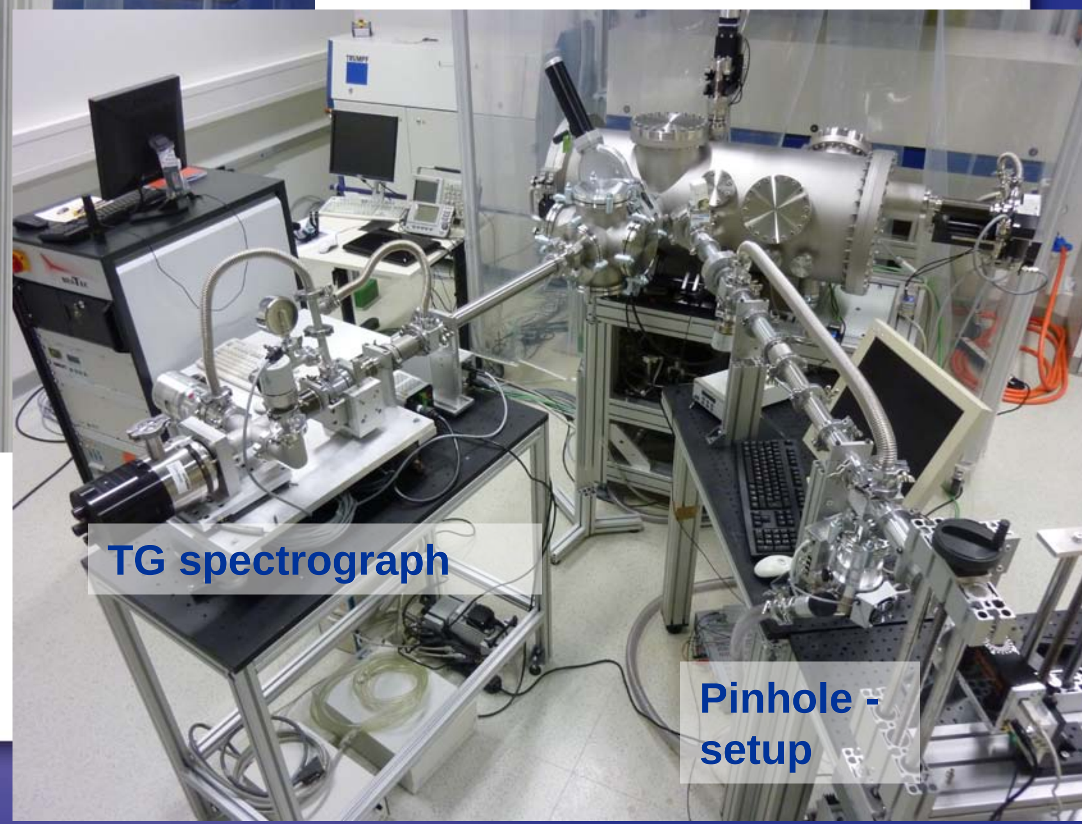
3.2 Current setup



Flexible design with two beamlines and changeable target material



Summary

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1. Diode-pumped thin disk laser system
   - Compact and robust systems
   - High average power
   - High stability and beam quality
   - Flexible pulse duration for optimized plasma heating
2. LPP sources:
   - Liquid jet technology:
     - Low debris, intense line emission, different liquids
   - Cylinder target technology:
     - Broadband & line emission, different metals, high CE

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Collaborations

BLiX Berlin Laboratory for innovative X-ray Technologies

1. Laser system

TRUMPF

FBH

2. X-ray microscope

Fraunhofer Institut Lasertechnik

BRUKER

Fraunhofer Institut Angewandte Optik und Feinmechanik

HZB Helmholtz Zentrum Berlin

KTH Vetenskap och Konst
KTH Physics

3. BLiX LPP source

BESTEC

4. Funding

Investitionsbank Berlin

EFRE …Aufschwung durch Europa!

Der Beauftragte der Bundesregierung für die Neuen Bundesländer

ptJ Projektträger Jülich Forschungszentrum Jülich

Bundesministerium für Bildung und Forschung

TU berlin

MBI

Thank you for your attention!